PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of

ALMANTAS GALVANAUSKAS, et al.

Appln. No.: 09/042,666

Confirmation No.: Not yet assigned

Group Art Unit: 2874

Filed: March 17, 1998

Examiner: J. LEE

For: ULTRASHORT-PULSE SOURCE WITH CONTROLLABLE WAVELENGTH OUTPUT

RESPONSE

Commissioner for Patents
Washington, D.C. 20231

Sir:

The present is in response to the non-final office action of September 5, 2001. In view of the comments which follow, favorable reconsideration of the subject application is respectfully requested.

Claims 1-13, 29 and 30 of the application stand rejected over the combination of Arbore and newly cited Sanders, taken with the Huber patent in the case of claims 12 and 13. Applicants respectfully traverse these rejections, inasmuch as none of the prior art relates to a device of the class claimed.

The invention relates broadly to the use of waveguide-form optical parametric generators for use as wavelength conversion devices for ultrashort optical pulses.

The references cited by the Examiner do not use or even mention optical parametric generators (OPG). As the Examiner does not appear to distinguish between optical parametric amplifiers (OPA), optical parametric oscillators (OPO), and optical parametric generators (OPG), Applicants believe that it may be appropriate to briefly explain the differences between these devices, inasmuch as there are fundamental distinctions to be drawn between not only the devices themselves, but the operational principles that they employ.

OPO and OPA can be understood in the context of sum frequency generation and difference frequency generation. Both are three-frequency interactions where a non-linear media receives a pair of input waves which interact within the media to generate a third wave at a different frequency. In sum frequency generation, energy flows from the lower frequency input to the higher frequency output, without gain. Second harmonic generation (SHG) is a special case of sum frequency generation where the two inputs are at the same frequency.

In difference frequency generation, the pump is the high frequency component and energy flows to the lower frequency output with the possibility of gain. Parametric amplification (OPA) can take place in the case where a strong input pump and a weak input signal are input to the non-linear media, causing the signal to be amplified using the pump energy. The third frequency output is generally discarded since the amplified signal is the wave of interest in this case, and if significant amplification is desired, an optical cavity must be arranged so that the signal can pass through the non-linear media a large number of times. It is possible to grow the signal wave from noise through multiple passes without inputting a signal wave, to produce an optical parametric oscillator (OPO).

The difficulties with such systems are, generally, the need for two or more synchronized sources at differing frequencies, and/or precisely tuned optical cavities, as documented in the present specification, for example at pages 2 – 3.

In contrast, optical parametric generation, sometimes known as superfluorescence, relates to the amplification of noise photons to a large signal in a single pass through the media, with a gain variously estimated at roughly e^{50} or 10^9. It is this phenomena that is disclosed and claimed in this application. As explained by the present application, the drawback with this approach to tunable frequency conversion has been the high threshold for OPG onset, typically approaching the optical damage limit of the nonlinear media, and requiring a high power laser source. The invention solves this drawback by creating a waveguide OPG system wherein the OPG threshold is reduced by a factor of greater than 100 as compared with the lowest values heretofore achieved. This breakthrough allows the development of a new class of devices, using sources having energy outputs easily reachable by ultrashort pulse fiber lasers, for example.

The prior art cited by the Examiner falls far short of teaching the basic combination of the invention, even with the addition of the newly cited Sanders patent, as discussed in more detail below.

First regarding the Arbore patent, the deficiencies of this patent as a reference against the present claims have been well documented in prior responses. Applicants would add in this response the fact that the passage quoted by the Examiner at col. 6, lines 44 – 60 has nothing to do with "quasi-phase matched OPG elements" as the Examiner would have it. A review of this section of Arbore reveals that it is discussing only second harmonic generation, which as noted above is a special case of sum frequency generation. OPG, or for that matter OPA or OPO, are not at all mentioned in the passage is question.

Arbore does not in fact even mention OPG in his disclosure. OPA is mentioned only in passing at column 12, lines 59 – 66, as a possible (but there non-enabled) alternative to SHG as a frequency conversion process.

Similar comments are in order regarding the Sanders patent. Sanders uses QPM difference frequency generation or QPM OPO in his system. Like Arbore, Sanders never even mentions OPG. This is not surprising given that OPG is impossible in the Sanders system. The present invention succeeds in reducing the OPG threshold to a peak power of around 250 watts (see Fig. 3) corresponding to a waveguide efficiency of 60%/W. By contrast, Sander's waveguide achieved an efficiency of 0.008%/W (see Col. 9, line 31) and a gain of about 0.004%, clearly proving the impossibility of OPG. Correspondingly, whereas the invention achieves 25% conversion to the signal of interest (see p. 9, lines 25 – 27), Sanders obtained 1.4×10^{-5} (see e.g., Fig. 4). Clearly, with the level of technology represented by Sanders, it would have been inconceivable to even consider OPG as a wavelength conversion methodology.

In view of the foregoing, applicants' invention, which claims waveguide based OPG wavelength conversion, would not have been obvious, and in fact would have been impossible, from any combination of the reference teachings. On this basis, reconsideration and favorable disposition are respectfully solicited.

In view of the above, reconsideration and allowance of this application are now believed to be in order, and such actions are hereby solicited. If any points remain in issue which the Examiner feels may be best resolved through a personal or telephone interview, the Examiner is kindly requested to contact the undersigned at the telephone number listed below.

Applicants hereby petition for any extension of time which may be required to maintain the pendency of this case, and any required fee, except for the Issue Fee, for such extension is to be charged to Deposit Account No. 19-4880.

Respectfully submitted,

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